



US006343643B1

(12) **United States Patent**
Bollesen

(10) **Patent No.:** **US 6,343,643 B1**
(45) **Date of Patent:** **Feb. 5, 2002**

(54) **CABINET ASSISTED HEAT SINK**
(75) Inventor: **Vernon P. Bollesen**, Milpitas, CA (US)
(73) Assignee: **Sun Microsystems, Inc.**, Palo Alto, CA (US)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

| | | | |
|---------------|---------|--------------------|----------|
| 5,570,271 A | 10/1996 | Lavochkin | 361/704 |
| 5,586,005 A | 12/1996 | Cipolla et al. | 361/719 |
| 5,621,244 A | 4/1997 | Lin | 257/713 |
| 5,699,229 A | 12/1997 | Brownell | 361/719 |
| 5,705,850 A * | 1/1998 | Ashiwake et al. | 257/719 |
| 5,748,446 A | 5/1998 | Feightner et al. | 361/709 |
| 5,751,062 A * | 5/1998 | Daikoku et al. | 257/718 |
| 5,761,041 A | 6/1998 | Hassanzadeh et al. | 361/704 |
| 5,847,928 A | 12/1998 | Hinshaw et al. | 361/704 |
| 5,881,800 A | 3/1999 | Chung | 165/80.3 |
| 5,884,692 A | 3/1999 | Lee et al. | 165/80.3 |
| 5,926,369 A * | 7/1999 | Ingraham et al. | 165/80.3 |
| 5,944,093 A * | 8/1999 | Viswanath | 165/80.3 |
| 5,959,350 A | 9/1999 | Lee et al. | 257/712 |
| 5,991,151 A | 11/1999 | Capriz | 361/704 |

(21) Appl. No.: **09/464,321**
(22) Filed: **Dec. 15, 1999**

(51) **Int. Cl.**⁷ **F28F 7/00**
(52) **U.S. Cl.** **165/80.3**; 165/104.33;
165/185; 361/700; 361/704; 257/722; 257/718;
257/719
(58) **Field of Search** 165/803, 185,
165/104.33, 104.21, 104.26; 361/704, 700;
257/714, 715, 722, 718, 719

FOREIGN PATENT DOCUMENTS

| | | | |
|----|-----------|-----------|------------|
| JP | 0113354 | * 10/1978 | 165/104.33 |
| JP | 354020669 | * 2/1979 | 257/719 |
| JP | 357147255 | * 9/1982 | 257/719 |

* cited by examiner

(56) **References Cited**

U.S. PATENT DOCUMENTS

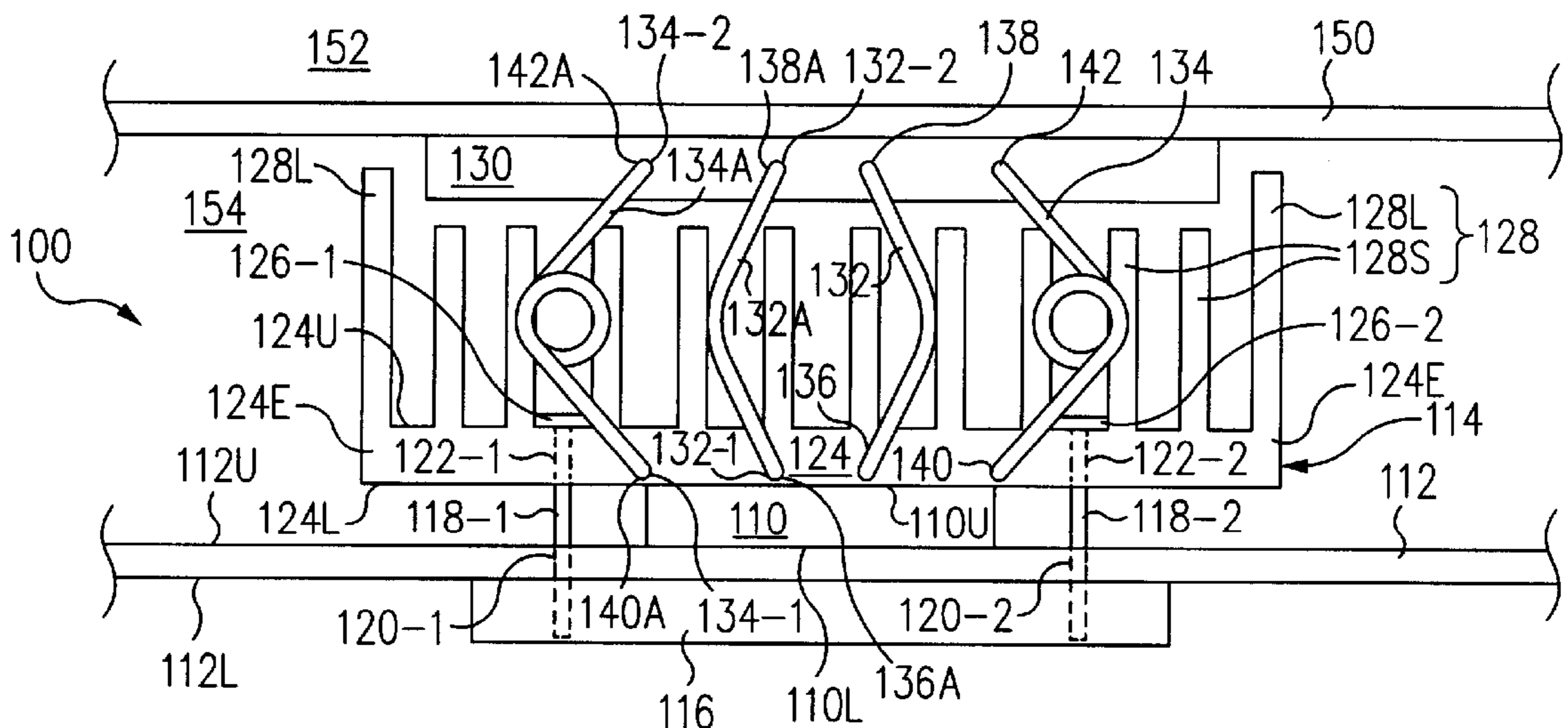
| | | | |
|---------------|---------|-------------------|------------|
| 4,972,294 A | 11/1990 | Moses, Jr. et al. | 361/386 |
| 5,022,462 A * | 6/1991 | Flint et al. | 165/80.3 |
| 5,036,384 A * | 7/1991 | Umezawa | 257/719 |
| 5,077,638 A | 12/1991 | Andersson et al. | 361/388 |
| 5,162,974 A * | 11/1992 | Carrie | 165/80.3 |
| 5,208,731 A | 5/1993 | Blomquist | 361/386 |
| 5,253,702 A | 10/1993 | Davidson et al. | 165/80.4 |
| 5,276,585 A | 1/1994 | Smithers | 361/704 |
| 5,283,467 A * | 2/1994 | Goeschel et al. | 165/80.3 |
| 5,307,239 A | 4/1994 | McCarty et al. | 361/704 |
| 5,329,426 A | 7/1994 | Villani | 361/719 |
| 5,329,993 A | 7/1994 | Ettehadih | 165/104.14 |
| 5,343,362 A | 8/1994 | Solberg | 361/710 |
| 5,367,193 A | 11/1994 | Malladi | 257/707 |
| 5,373,099 A | 12/1994 | Boitard et al. | 174/16.3 |
| 5,423,375 A | 6/1995 | Chiou | 165/80.3 |

Primary Examiner—Christopher Atkinson
(74) *Attorney, Agent, or Firm*—Gunnison, McKay & Hodgson, L.L.P.; Serge J. Hodgson

(57) **ABSTRACT**

A heat sink structure includes a lower heat sink in thermal contact with a heat emitting component. The heat sink structure further includes an upper heat sink and at least one heat pipe extending from the lower heat sink to the upper heat sink. At least one spring urges the upper heat sink away from the lower heat sink and into thermal contact with a cabinet, sometimes called a cover or a lid, of a computer system. During use, the heat emitting component generates heat. This heat is conducted to the lower heat sink, the upper heat sink, and the cabinet. The cabinet dissipates heat to the outside of the computer system.

23 Claims, 5 Drawing Sheets



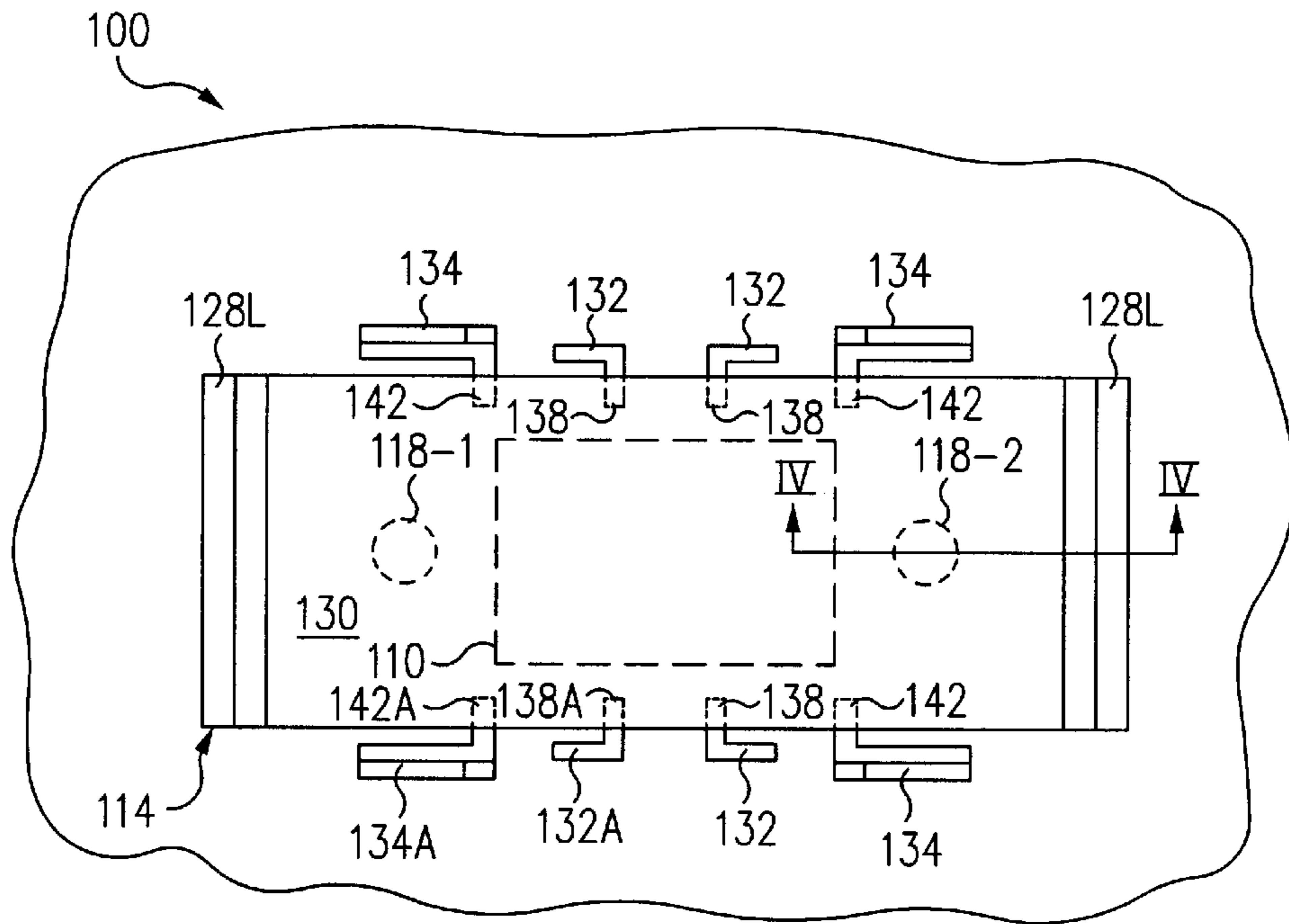


FIG. 1

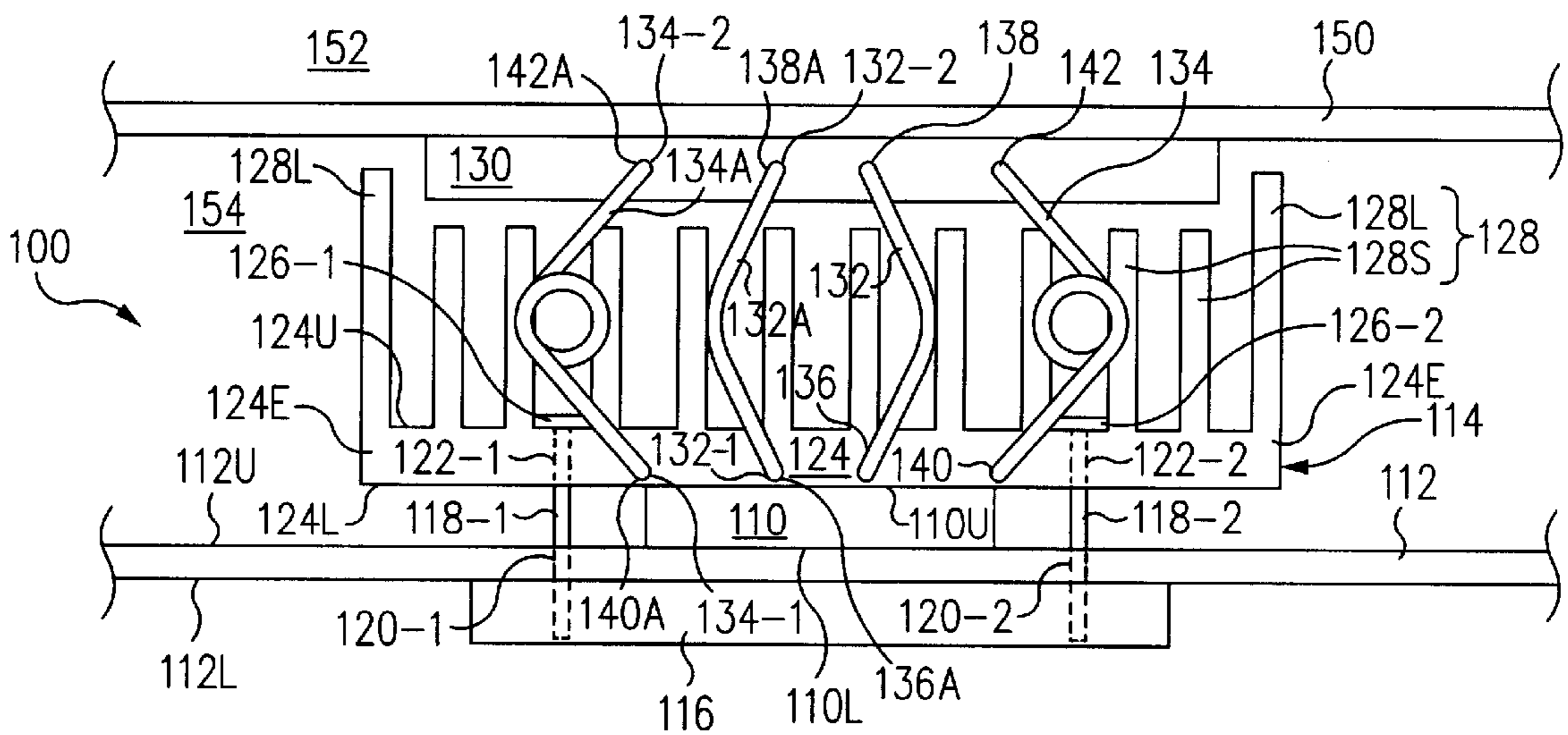


FIG. 2

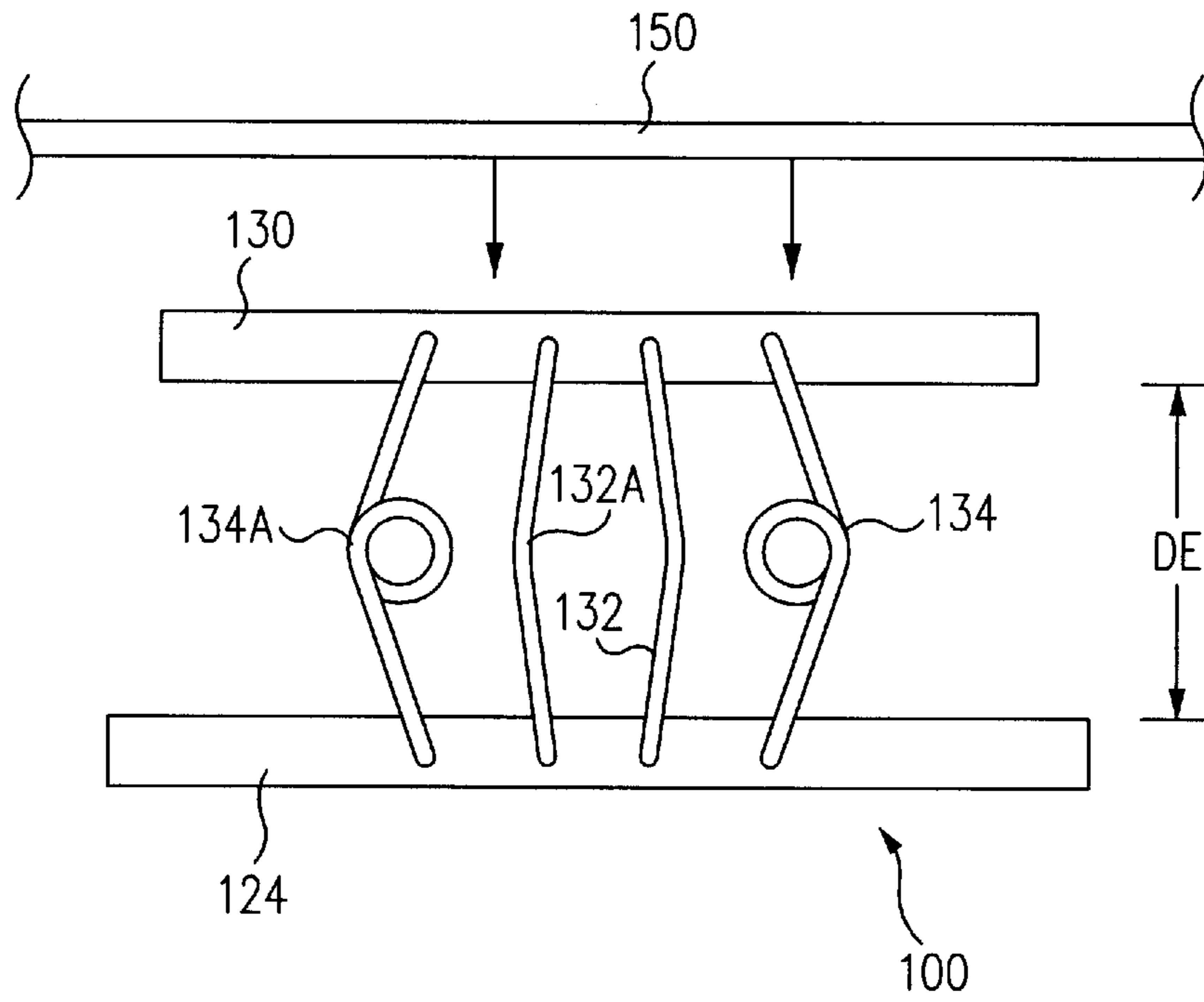


FIG. 3A

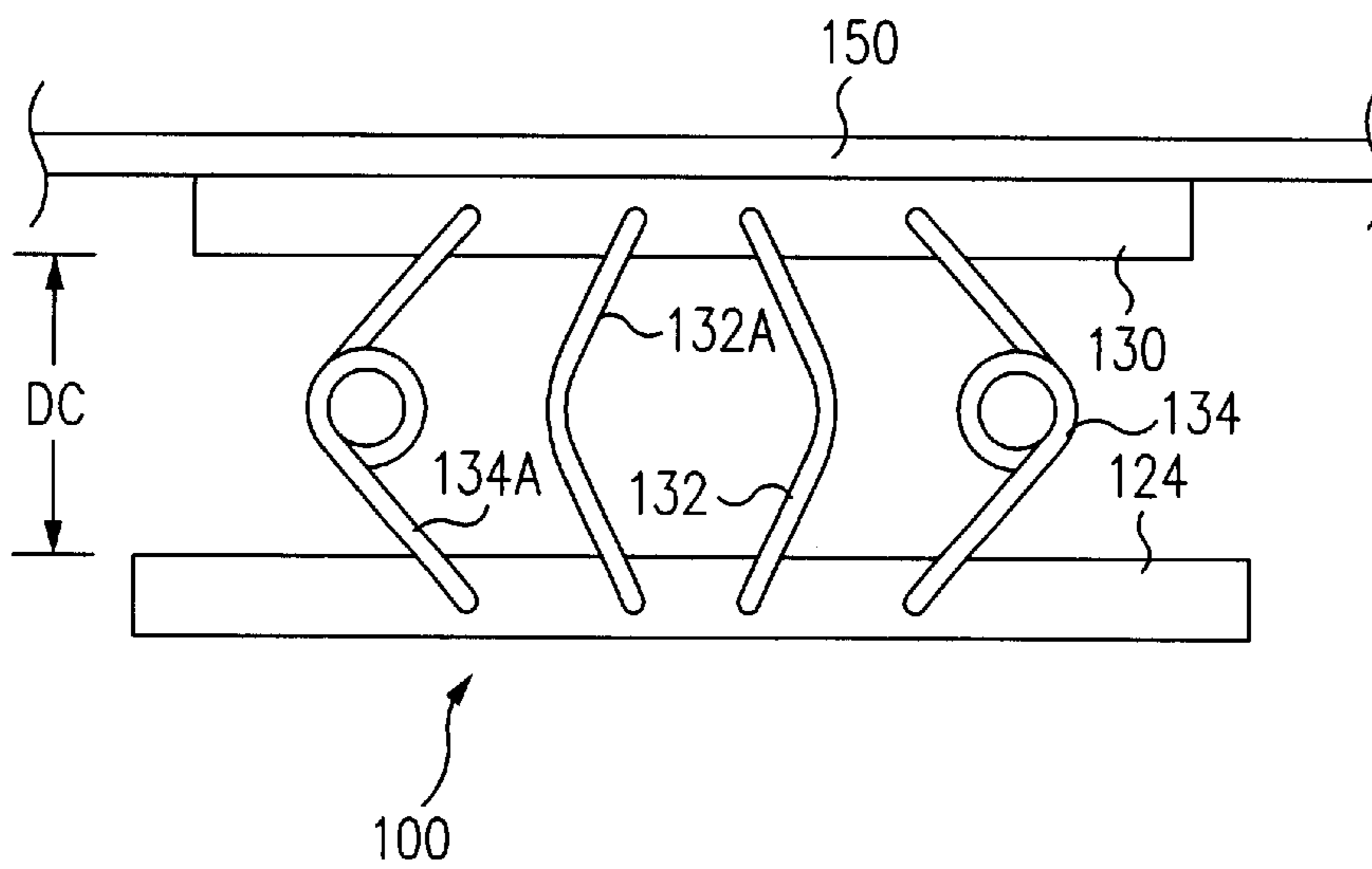


FIG. 3B

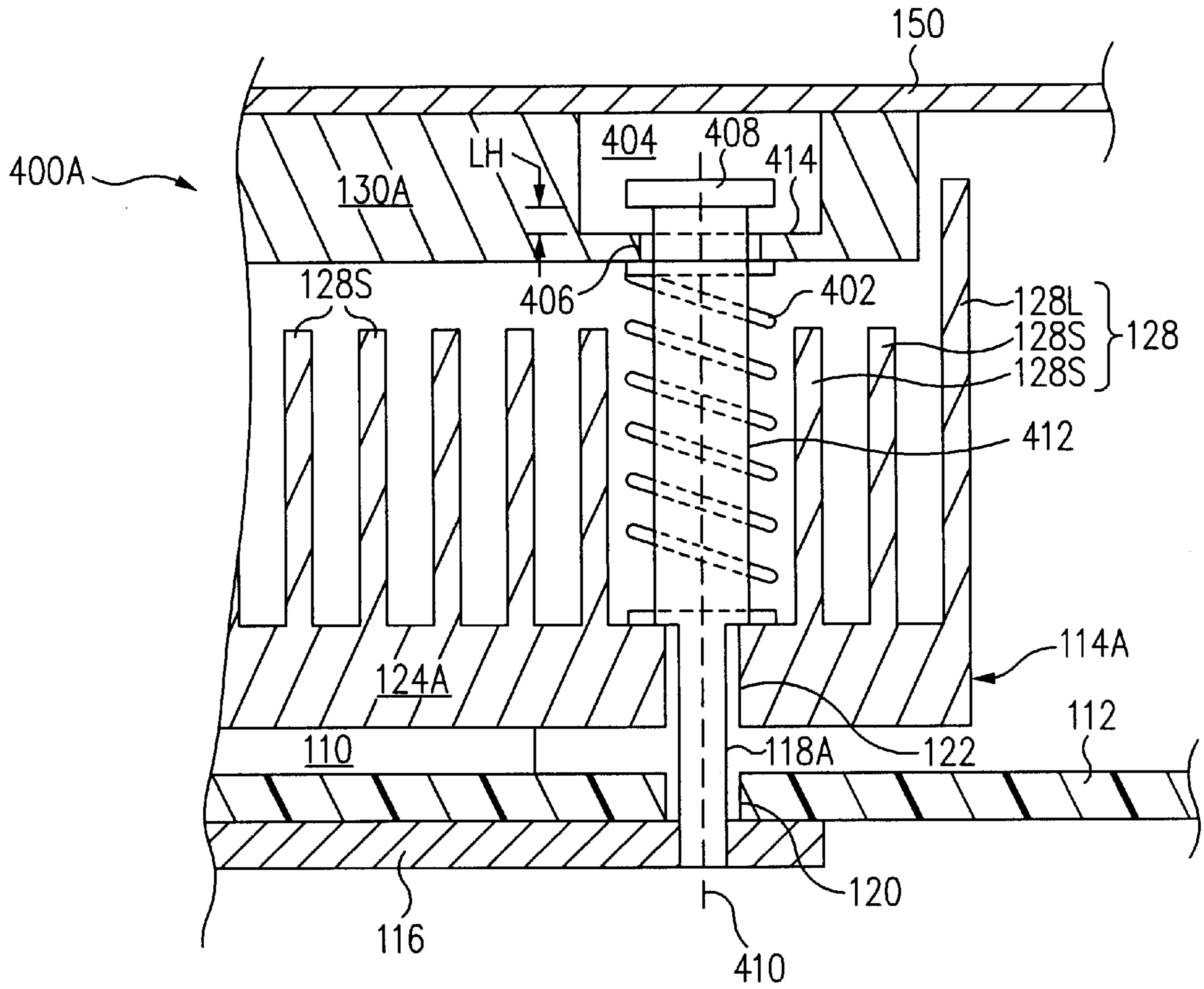


FIG. 4A

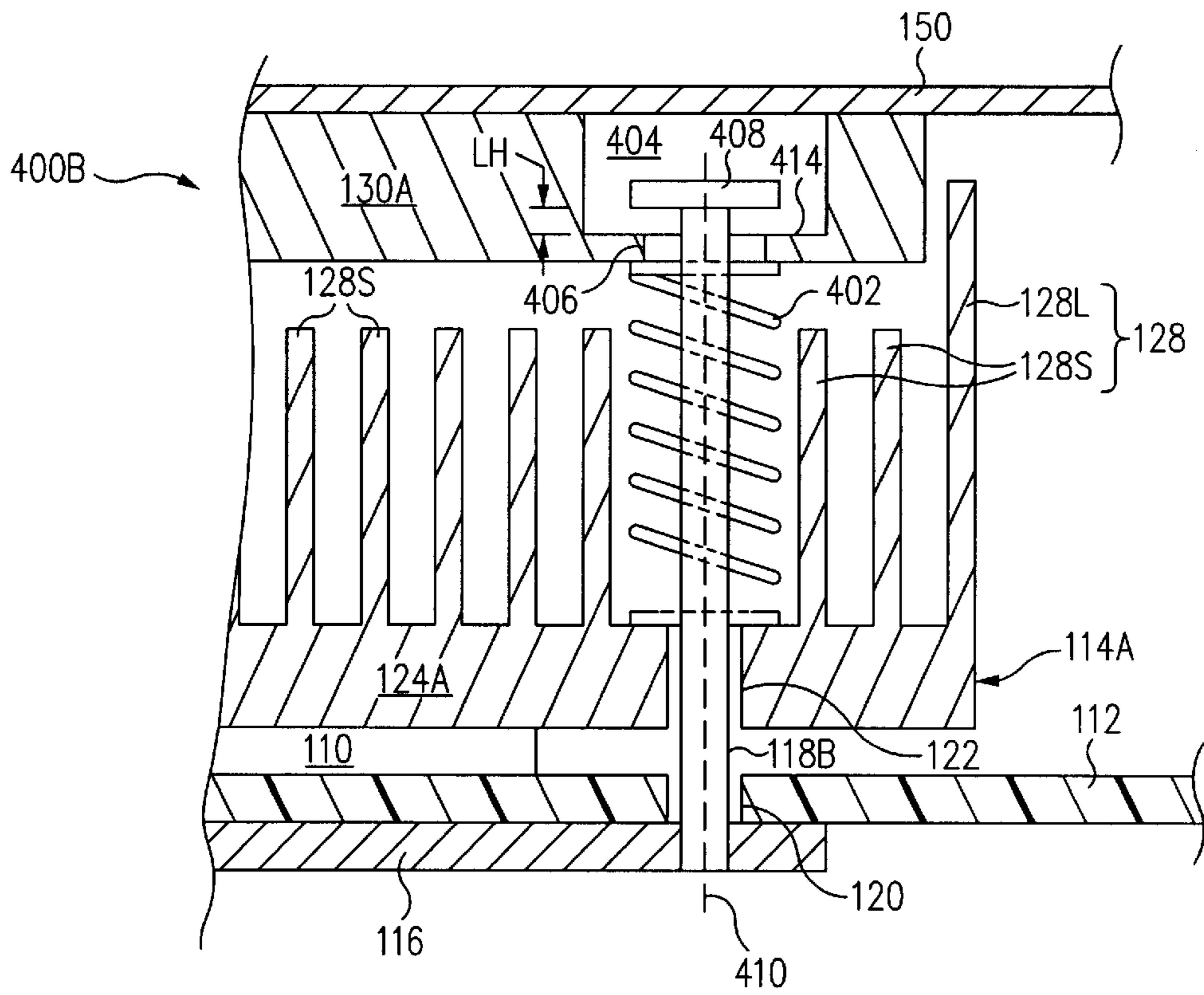


FIG. 4B

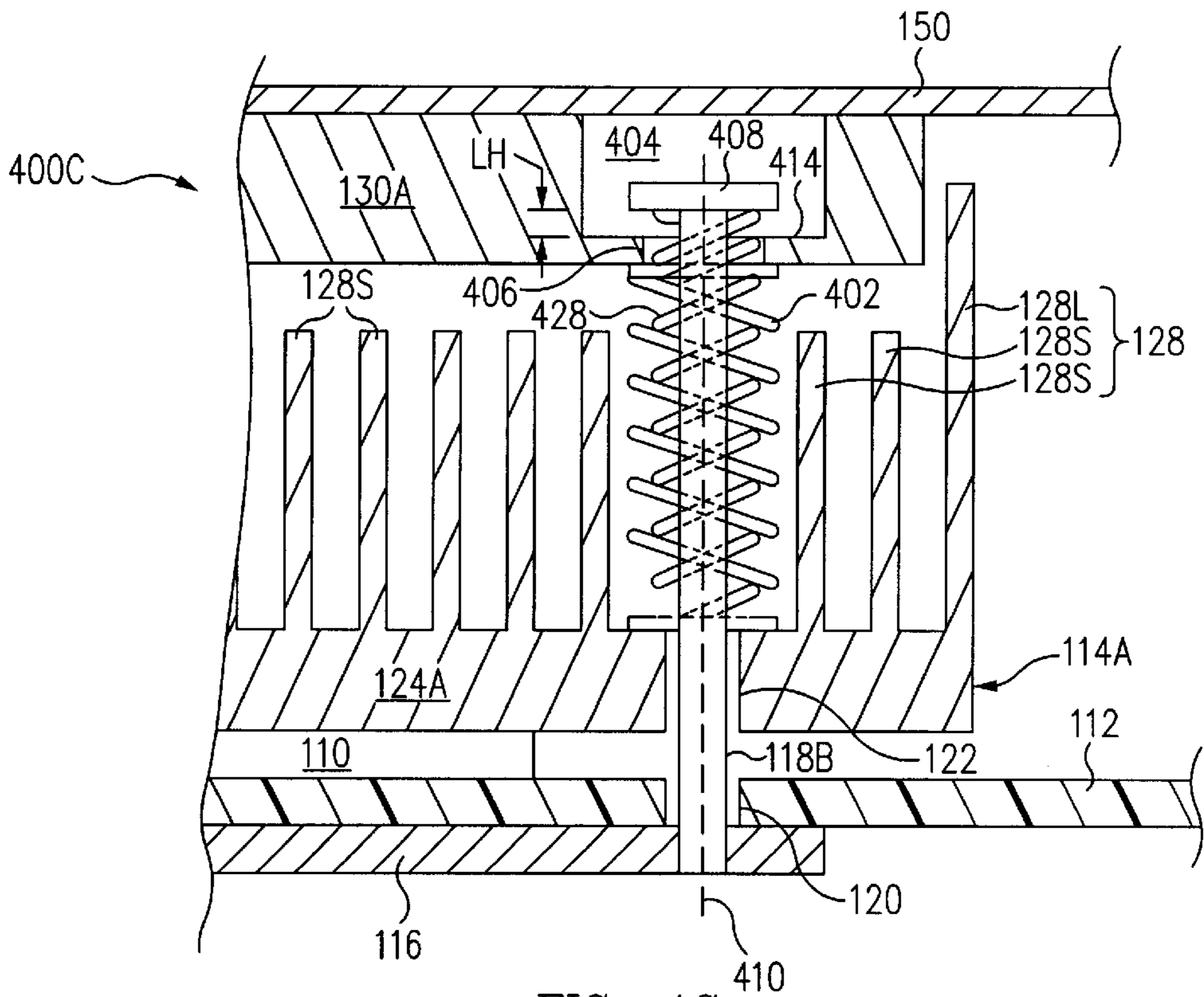


FIG. 4C

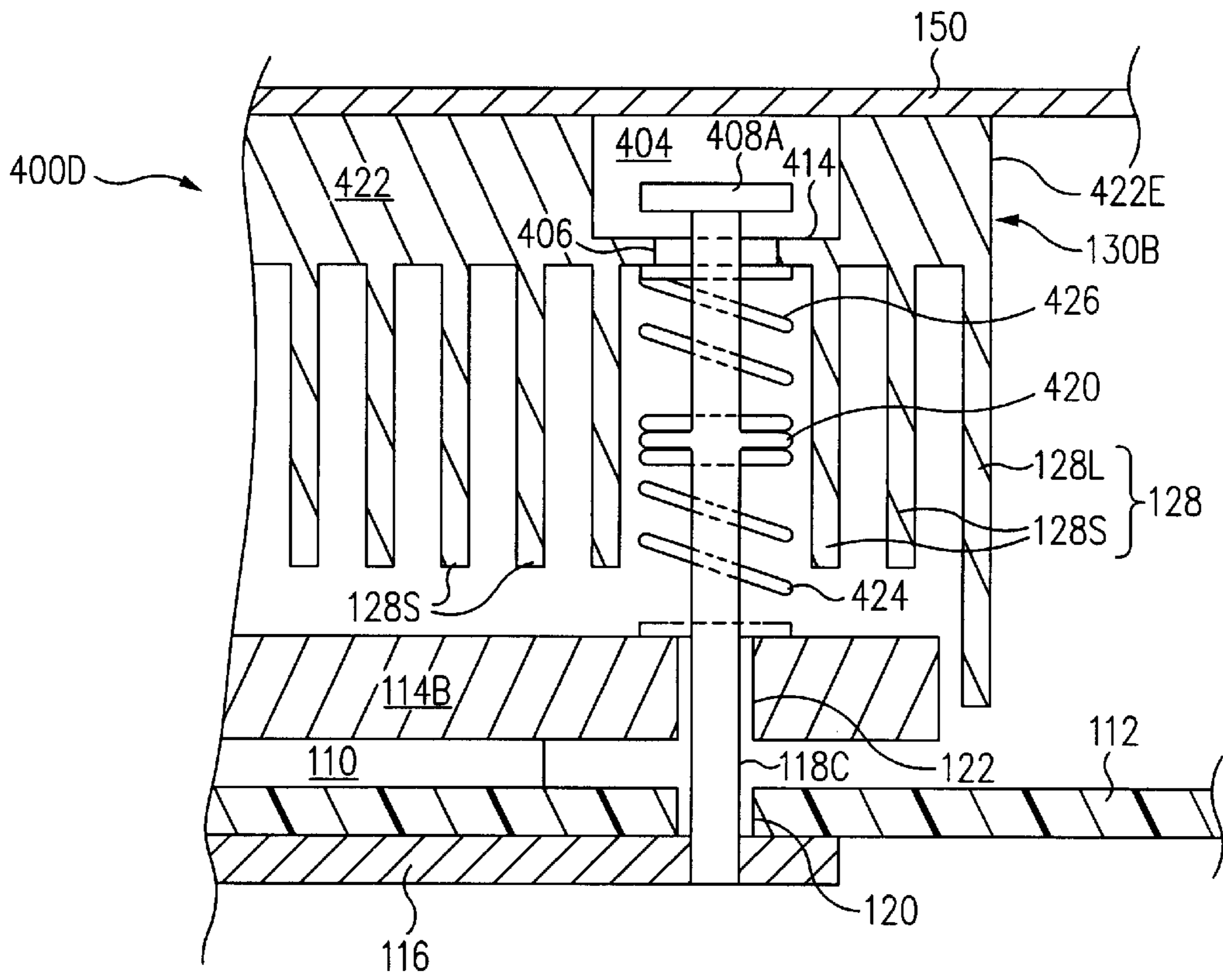


FIG. 4D

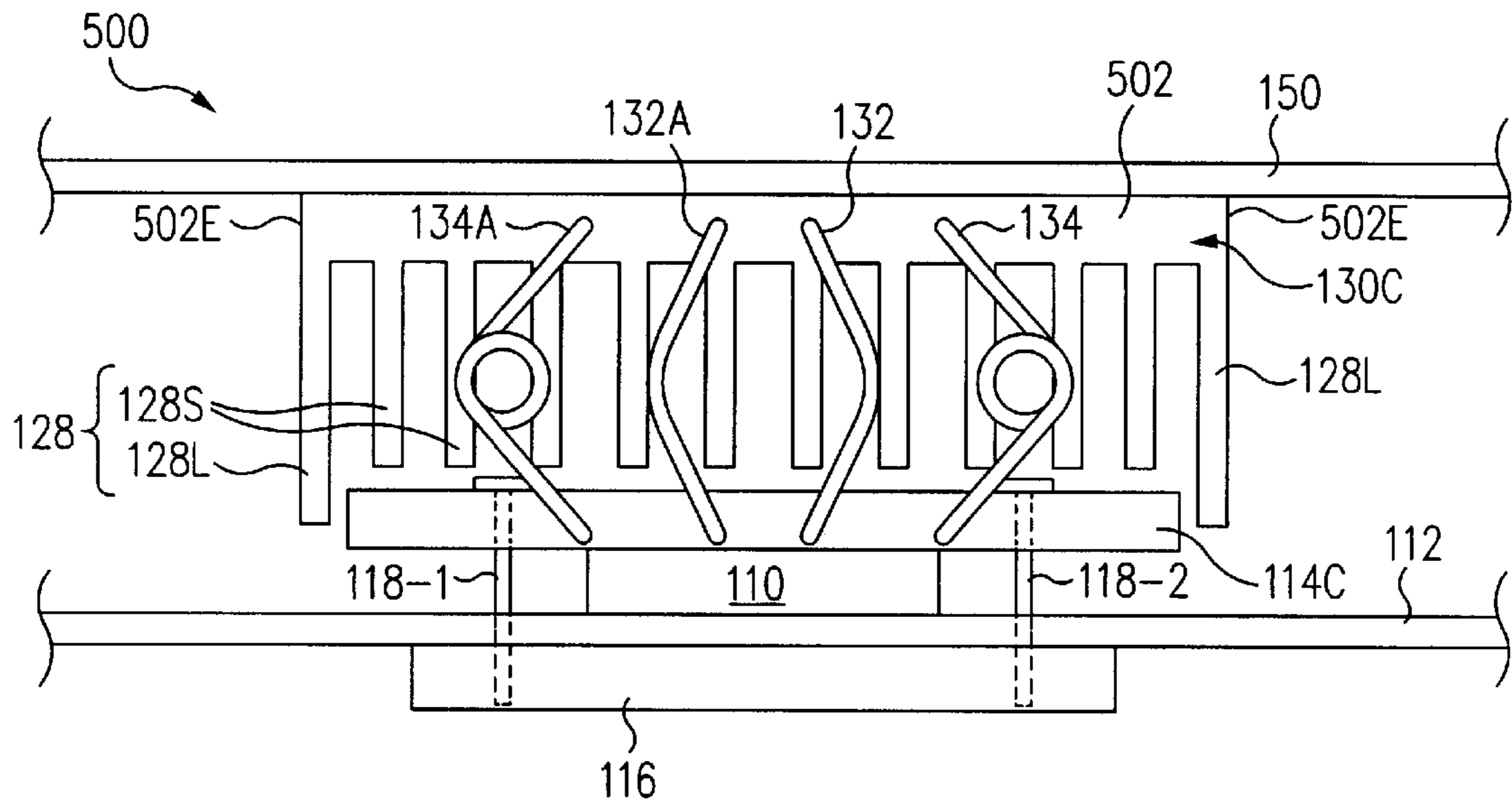


FIG. 5

CABINET ASSISTED HEAT SINK

FIELD OF THE INVENTION

The present invention relates generally to cooling of electronic components in electronic devices. More particularly, the present invention relates to a heat sink structure which uses a cabinet of an electronic device.

BACKGROUND OF THE INVENTION

As the art moves towards higher power integrated circuits and components, hereinafter referred to as heat emitting components, heat transfer from the heat emitting components becomes increasingly difficult and more important. One conventional technique to remove heat from a heat emitting component is to employ a finned heat sink which is placed in thermal contact with the heat emitting component. In this manner, heat generated by the heat emitting component is conducted to the heat sink and then dissipated to the ambient environment.

Hassanzadeh et al., U.S. Pat. No. 5,761,041, which is herein incorporated by reference in its entirety, teaches a finned heat sink which is placed in thermal contact with a heat emitting component. To mount the heat sink, a bolster plate is positioned below a printed circuit board, and two pins extend up from the bolster plate, through the printed circuit board and through the base of the heat sink. A spring, engaged with the two pins, presses the heat sink into thermal contact with the heat emitting component.

Although the heat sink of Hassanzadeh et al. is suitable for its intended purpose, in some applications, there is only limited space for the heat sink. In these applications, the size of the heat sink which can be placed in the limited space is not adequate to sufficiently cool the heat emitting component. To enhance heat transfer from the heat emitting component and heat sink in this event, additional and/or more powerful fans are often used. However, to avoid excess power consumption and to avoid exceeding noise level limits, the size of these additional and/or more powerful fans is severely restricted.

Accordingly, the art needs a method of enhancing heat transfer from a heat emitting component where there is only limited space for a heat sink and without providing additional and/or more powerful fans.

SUMMARY OF THE INVENTION

In accordance with the present invention, a heat sink structure includes a lower heat sink in thermal contact with a heat emitting component. The heat sink structure further includes an upper heat sink and at least one heat pipe extending from the lower heat sink to the upper heat sink. At least one spring urges the upper heat sink away from the lower heat sink and into thermal contact with a cabinet, sometimes called a cover or a lid, of a system such as a computer system.

During use, the heat emitting component generates heat. This heat is conducted to the lower heat sink which dissipates some of this heat to the ambient environment. Further, some of the heat is conducted from the lower heat sink to the upper heat sink through the at least one heat pipe. The upper heat sink also dissipates some of this heat to the ambient environment. At the same time, some of the heat from the upper heat sink is conducted to the cabinet.

Since the cabinet has a relatively large surface area and is exposed to the outside of the computer system which is relatively cool compared to the inside of the computer

system, the cabinet is extremely effective at dissipating heat to the ambient environment, and in particular, to the outside of the computer system.

Recall that in the prior art, fans were utilized to remove heat from inside of the computer system. However, as the art moved to higher power components, the amount of heat which had to be removed from the computer system increased. This additional heat was removed by providing additional and/or more powerful fans. Disadvantageously, these additional and/or more powerful fans consumed more power which increased operating cost of the computer system. Further, these additional and/or more powerful fans resulted in an increase in noise which was detrimental to the performance of the computer system.

In contrast, a heat sink structure in accordance with the present invention removes heat from inside of a system such as a computer system directly through the cabinet and to the outside. Advantageously, this heat is removed without having to power a fan and without generating noise. Accordingly, the prior art requirement of providing additional and/or more powerful fans is eliminated.

Further, since the heat sink structure utilizes the cabinet to enhance heat dissipation from the heat emitting component, the heat sink structure is well-suited for use when only a limited amount of space is available for the heat sink, i.e., when the distance between the heat emitting component and the cabinet is relatively small.

Also in accordance with the present invention, a method includes pressing a lower heat sink into thermal contact with a heat emitting component. An upper heat sink is supported above the lower heat sink, the lower heat sink being a thermally connected to the upper heat sink. The method further includes pressing the upper heat sink against a cabinet.

These and other features and advantages of the present invention will be more readily apparent from the detailed description set forth below taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1 and 2 are top and side plan views, respectively, of a heat sink structure in accordance with the present invention.

FIGS. 3A and 3B are side plan views illustrating a heat sink structure in accordance with the present invention prior to and after, respectively, installation of a cabinet.

FIGS. 4A, 4B, 4C and 4D are cross-sectional views of heat sink structures along the line IV—IV of FIG. 1 in accordance with various alternative embodiments of the present invention.

FIG. 5 is a side plan view of a heat sink structure in accordance with yet another alternative embodiment of the present invention.

In the following description, similar elements are labeled with similar reference numbers.

DETAILED DESCRIPTION

In accordance with the present invention, a heat sink structure **100** (FIGS. 1, 2) includes a lower heat sink **114** in thermal contact with a heat emitting component **110**. Heat sink structure **100** further includes an upper heat sink **130** and heat pipes **132** extending from lower heat sink **114** to upper heat sink **130**. Springs **134** urge upper heat sink **130** away from lower heat sink **114** and into thermal contact with a cabinet **150** (FIG. 2), sometimes called a cover or a lid, of a system such as a computer system.

During use, heat emitting component **110** generates heat. This heat is conducted to lower heat sink **114** which dissipates some of this heat to the ambient environment. Further, some of the heat is conducted from lower heat sink **114** to upper heat sink **130** through heat pipes **132**. Upper heat sink **130** dissipates some of this heat to the ambient environment. At the same time, some of the heat from upper heat sink **130** is conducted to cabinet **150**.

Since cabinet **150** has a relatively large surface area and is exposed to the outside of the computer system, i.e., region **152**, which is relatively cool compared to the inside of the computer system, i.e., region **154**, cabinet **150** is extremely effective at dissipating heat to the ambient environment, and in particular, to the outside of the computer system.

Recall that in the prior art, fans were utilized to remove heat from the inside of the computer system. However, as the art moved to higher power components, the amount of heat which had to be removed from the computer system increased. This additional heat was removed by providing additional and/or more powerful fans. Disadvantageously, these additional and/or more powerful fans consumed more power which increased the operating cost of the computer system. Further, these additional and/or more powerful fans resulted in an increase in noise which was detrimental to the performance of the computer system.

In contrast, heat sink structure **100** in accordance with the present invention removes heat from inside of a system directly through cabinet **150** and to the outside. Advantageously, this heat is removed without having to power a fan and without generating noise. Accordingly, the prior art requirement of providing additional and/or more powerful fans is eliminated.

Further, since heat sink structure **100** utilizes cabinet **150** to enhance heat dissipation from heat emitting component **110**, heat sink structure **100** is well-suited for use when only a limited amount of space is available for a heat sink, i.e., when the distance between heat emitting component **110** and cabinet **150** is relatively small.

More particularly, FIGS. **1** and **2** are top and side plan views, respectively, of a heat sink structure **100** in accordance with present invention. Referring to FIGS. **1** and **2** together, a lower, e.g., first, surface **110L** of a heat emitting component **110** is attached to an upper, e.g., first, surface **112U** of a substrate **112** such as a printed circuit board. A lower, e.g., first, surface **124L** of a base section **124** of a heat sink **114** is in thermal contact with an upper, e.g., second, surface **110U** of heat emitting component **110**. Heat sink **114** further includes a plurality of fins **128** extending upwards, e.g., in a first direction, from base section **124**.

A bolster plate **116** is positioned opposite of heat emitting component **110** on a lower, e.g., second, surface **112L** of substrate **112**. Extending upward from bolster plate **116** are first and second pins **118-1**, **118-2**. Although two pins **118-1**, **118-2** (collectively pins **118**) are illustrated, in light of this disclosure, those of skill in the art will recognize that more than two pins **118** can be used, e.g., a pin **118** is located adjacent each corner of package **100** for a total of four pins **118**.

Pins **118-1**, **118-2** pass through apertures **120-1**, **120-2** in substrate **112** and through apertures **122-1**, **122-2** in base section **124** of heat sink **114**, respectively. Heads **126-1**, **126-2** of pins **118-1**, **118-2**, respectively, press downwards, e.g., in a second direction opposite the first direction, on an upper, e.g., second, surface **124U** of base section **124** of heat sink **114**.

Heat emitting component **110** is attached to upper surface **112U** of substrate **112** in a conventional manner. For

example, heat emitting component **110** is a ball grid array or a pin grid array type component. By positioning heat emitting component **110** and substrate **112** between heat sink **114** and bolster plate **116**, heat sink **114** is pressed into thermal contact with heat emitting component **110**.

In one embodiment, heat emitting component **110** is held in place on substrate **112** by heat sink **114**. For example, heat emitting component **110** includes a land grid array type central processing unit (CPU) and a socket which is located between the CPU and substrate **112**. In one embodiment, heat emitting component **110** includes a thermal pad and/or thermal grease between the CPU and heat sink **114**. Suitable CPUs, sockets, thermal pads and/or thermal greases are well known to those of skill in the art and are not illustrated in the figures or discussed further for the purposes of clarity.

Positioned above heat sink **114** is an upper, e.g., second, heat sink **130**. In this embodiment, upper heat sink **130** is a flat metal plate, i.e., is a plate type heat sink. Upper heat sink **130** is physically and thermally connected to heat sink **114**, which is a lower, e.g., first, heat sink in this embodiment (heat sink **114** is hereinafter referred to as lower heat sink **114**). More particularly, upper heat sink **130** is thermally connected to lower heat sink **114** by at least one heat pipe **132**. Further, upper heat sink **130** is physically connected to lower heat sink **114** by at least one spring **134**. In one embodiment, structure **100** includes four heat pipes **132** and four springs **134**.

Heat pipes **132** are formed of a material having a high thermal conductivity. In one embodiment, heat pipes **132** are 0.125 inch (3.18 millimeter) diameter. In accordance with this embodiment, ends of heat pipes **132** are attached to lower and upper heat sinks **114**, **130**.

To illustrate, a first end **132-1** of a first heat pipe **132A** of the plurality of heat pipes **132** is secured in a first aperture **136A** of a plurality of apertures **136** in base section **124** of lower heat sink **114**. A second end **132-2** of first heat pipe **132A** is secured in a first aperture **138A** of a plurality of apertures **138** in upper heat sink **130**.

Ends **132-1**, **132-2** are secured in apertures **136A**, **138A**, respectively, by friction, by an adhesive such as epoxy, by solder or by another suitable technique. However, in alternative embodiments, ends **132-1**, **132-2** of heat pipe **132A** are secured directly to the outer surfaces of lower and upper heat sinks **114**, **130**, respectively, using any one of a number of conventional techniques, for example, through the use of a pressure sensitive adhesive or solder. The other heat pipes **132** are secured to lower and upper heat sinks **114**, **130** in a similar manner.

Similarly, ends of springs **134** are secured in apertures in lower and upper heat sinks **114**, **130**. To illustrate, a first end **134-1** of a first spring **134A** of the plurality of springs **134** is secured in a first aperture **140A** of a plurality of apertures **140** in base section **124** of lower heat sink **114**. A second end **134-2** of first spring **134A** is secured in a first aperture **142A** of a plurality of apertures **142** in upper heat sink **130**.

Ends **134-1**, **134-2** are secured in apertures **140A**, **142A**, respectively, by friction, by an adhesive such as epoxy, by solder or by another suitable technique. However, in alternative embodiments, ends **134-1**, **134-2** of spring **134A** are secured directly to the outer surfaces of lower and upper heat sinks **114**, **130**, respectively, using any one of a number of conventional techniques, for example, through the use of a pressure sensitive adhesive or solder. The other springs **134** are secured to lower and upper heat sinks **114**, **130** in a similar manner.

Of importance, upper heat sink **130** is in thermal contact with a cabinet **150**, sometimes called a cover or a lid. To

illustrate, structure **100** is part of a larger system such as a computer system, and cabinet **150** is the outer cover of this system. However, as used herein, the term cabinet generally refers to any rigid structure. Preferably, cabinet **150** has a relatively high thermal conductivity, for example, cabinet **150** is metal.

During use, heat emitting component **110** generates heat. This heat is conducted to and heats lower heat sink **114**. Lower heat sink **114** dissipates some of this heat to the ambient environment. Fins **128** enhance this heat dissipation.

Further, some of the heat is conducted from lower heat sink **114** to upper heat sink **130** through heat pipes **132**. Upper heat sink **130** dissipates some of this heat to the ambient environment. At the same time, some of the heat from upper heat sink **130** is conducted to cabinet **150**. Since cabinet **150** has a relatively large surface area, cabinet **150** is extremely effective at dissipating heat to the ambient environment.

In one embodiment, cabinet **150** is the outer metal cover of system such as a computer system. Cabinet **150** defines an outer region **152** outside of the system and an inner region **154** inside of the system. Generally, outer region **152** is cooler than inner region **154**. Since cabinet **150** is exposed directly to outer region **152**, heat is readily dissipated from cabinet **150** to outer region **152**, and more particularly, to outside of the system.

Further, since cabinet **150** has a large surface area and is exposed to outer region **152**, a large temperature differential exists between heat emitting component **110** and cabinet **150**, i.e., cabinet **150** is relatively cool compared to heat emitting component **110**. As is well known to those of skill in the art, conductive heat transfer between a first item and a second item is directly proportional to the temperature differential existing between the first item and the second item. Accordingly, the large temperature differential between heat emitting component **110** and cabinet **150** drives heat from heat emitting component **110** to cabinet **150** which dissipates this heat to the ambient environment, and more particularly, to outside the system.

Recall that in the prior art, fans were utilized to remove heat from inside of the computer system. However, as the art moved to higher power components, the amount of heat which had to be removed from the computer system increased. This additional heat was removed by providing additional and/or more powerful fans. Disadvantageously, these additional and/or more powerful fans consumed more power which increased the operating cost of the computer system. Further, these additional and/or more powerful fans resulted in an increase in noise which was detrimental to the performance of the computer system.

In contrast, heat sink structure **100** in accordance with the present invention removes heat from inside of a system such as a computer system directly through cabinet **150** and to the outside environment. Advantageously, this heat is removed without having to power a fan and without generating noise. Accordingly, the prior art requirement of providing additional and/or more powerful fans is eliminated. Advantageously, operating costs are reduced and system performance is enhanced compared to the prior art.

Further, heat sink structure **100** is well suited for use when only a limited amount of space is available for a heat sink, i.e., when the distance between heat emitting component **110** and cabinet **150** is relatively small.

Of importance, heat sink structure **100** is used without making any modifications to cabinet **150**. In particular,

springs **134** support upper heat sink **130** when cabinet **150** is removed (or before cabinet **150** is installed). Springs **134** further ensure intimate thermal contact between upper heat sink **130** and cabinet **150** after cabinet **150** is installed as described in greater detail in reference to FIGS. **3A** and **3B**.

FIGS. **3A** and **3B** are side plan views illustrating a heat sink structure in accordance with the present invention prior to and after, respectively, installation of cabinet **150**. In FIGS. **3A** and **3B**, only base section **124**, upper heat sink **130**, heat pipes **132**, springs **134** and cabinet **150** are illustrated to avoid detracting from the principals of the invention.

Referring to FIG. **3A**, before installation of cabinet **150**, springs **134** are fully extended such that a distance **DE** between upper heat sink **130** and base section **124** exists. Heat pipes **132** have a sufficient length to extend from upper heat sink **130** to base section **124** of lower heat sink **114** when springs **134** are fully extended.

Of importance, upper heat sink **130** is fully supported above lower heat sink **114** by springs **134** even in the absence of cabinet **150**. Referring again to FIG. **2**, to prevent inadvertent horizontal motion of upper heat sink **130** relative to lower heat sink **114**, the outermost fins **128L** located at ends **124E** of base section **124** extend upwards alongside of upper heat sink **130**. In particular, fins **128L** are longer than inner fins **128S** located between fins **128L**.

Referring again to FIG. **3A**, to install cabinet **150** to the system, cabinet **150** is moved downwards towards upper heat sink **130**. Cabinet **150** contacts upper heat sink **130** and moves upper heat sink **130** along with cabinet **150** downwards towards base section **124**. This compresses heat pipes **132** and springs **134** as shown in FIG. **3B**. Cabinet **150** is secured in place as is well known to those of skill in the art, e.g., using screws.

Referring now to FIG. **3B**, once cabinet **150** is secured in place, a distance **DC** between upper heat sink **130** and base section **124** exists. Since distance **DC** is less than distance **DE** between upper heat sink **130** and base section **124** when springs **134** are fully extended, springs **134** are under tension when cabinet **150** is secured in place. This tension causes springs **134** to urge upper heat sink **130** upwards away from lower heat sink **114** and against cabinet **150**. By pressing upper heat sink **130** against cabinet **150**, intimate thermal contact between upper heat sink **130** and cabinet **150** is achieved. Further, heat pipes **132** are made of a material having a sufficient flexibility to bend when upper heat sink **130** is moved downwards towards base section **124**.

Of importance, upper heat sink **130** is not directly bolted to cabinet **150** allowing cabinet **150** to be readily removed. This simplifies servicing and avoids the possibility of damaging heat sink structure **100** by inadvertently removing cabinet **150** without first unbolted upper heat sink **130** from cabinet **150**. However, in an alternative embodiment, upper heat sink **130** is bolted directly to cabinet **150**.

In FIGS. **1**, **2**, **3A** and **3B**, springs **134** are illustrated as having a particular shape. However, in alternative embodiments, other types of springs are used. For example, as set forth below in FIGS. **4A** and **4B**, coil springs used.

FIG. **4A** is a cross-sectional view of a heat sink structure **400A** along the line IV—IV of FIG. **1** in accordance with an alternative embodiment of the present invention. Heat sink structure **400A** of FIG. **4A** is substantially similar to heat sink structure **100** of FIGS. **1** and **2** with the primary exception that springs **134** of structure **100** have been replaced with springs **402** of structure **400A**. Only the relevant differences between heat sink structure **100** of FIG.

1 and heat sink structure 400A of FIG. 4A are discussed below. Further, although only a single spring 402 and pin 118A are illustrated in FIG. 4A and discussed below, in light of this disclosure, it is understood that a plurality of springs 402 and pins 118A are used, e.g., two or four.

Referring to FIG. 4A, an upper heat sink 130A defines a pinhead cavity 404. In accordance with this embodiment, a pin 118A extends upwards from bolster plate 116 through an aperture 120 of substrate 112, through an aperture 122 of a base section 124A of a lower heat sink 114A, through an aperture 406 of upper heat sink 130A and into pinhead cavity 404.

Pinhead cavity 404 has a diameter greater than a diameter of a head 408 of pin 118A so that upper heat sink 130A has freedom to move in the vertical direction. However, head 408 of pin 118A has a diameter greater than a diameter of aperture 406 of upper heat sink 130A. In this manner, the freedom of upper heat sink 130A to move in the vertical direction is limited. More particularly, upper heat sink 130A is free to move downwards (although spring 402 will resist this motion as discussed further below) until upper heat sink 130A contacts fins 128S and is free to move upwards until upper heat sink 130A contacts head 408 of pin 118A.

Spring 402, e.g., a coil spring, surrounds pin 118A such that pin 118A and spring 402 have a common longitudinal axis 410. In this embodiment, pin 118A has a pin portion 412 which has an outer diameter approximately equal to, but slightly smaller than, the inner diameter of spring 402. Pin portion 412 extends between head 408 and base section 124A in this embodiment.

Spring 402 presses downwards against base section 124A of lower heat sink 114A and upwards against upper heat sink 130A. As a result, spring 402 urges upper heat sink 130A upwards and away from lower heat sink 114A.

Prior to installation of cabinet 150, spring 402 urges upper heat sink 130A, and more particularly, urges a landing 414 of pinhead cavity 404, against head 408 of pin 118A. Advantageously, upper heat sink 130A is supported by pin 118A in combination with spring 402 when cabinet 150 is removed (or before cabinet 150 is installed).

In a manner similar to that described in reference to FIGS. 3A and 3B, upper heat sink 130A is moved downwards towards lower heat sink 114A during installation of cabinet 150. Thus, when cabinet 150 is installed as shown in FIG. 4A, a vertical distance LH between landing 414 and head 408 is equal to the distance which upper heat sink 130A moved downwards during installation of cabinet 150. Spring 402 continues to press upper heat sink 130A upwards and into intimate thermal contact with cabinet 150.

To assemble heat sink structure 400A of FIG. 4A, pin 118A is passed downwards through aperture 406 of upper heat sink 130A. Pin 118A is then passed through spring 402, through aperture 122 in base section 124A and through aperture 120 in substrate 112. Pin 118A is attached to bolster plate 116 using any one of a number of conventional techniques. For example, pin 118A is screwed or riveted into bolster plate 116.

As pin 118A is attached to bolster plate 116, lower heat sink 114A is simultaneously pressed into thermal contact with heat emitting component 110. In one embodiment, pin portion 412 of pin 118A has a greater diameter than aperture 122 in base section 124A. In this embodiment, as pin 118A is attached to bolster plate 116, pin portion 412 and spring 402 press downwards against base section 124A. This, in turn, causes lower heat sink 114A to press downwards against heat emitting component 110.

FIG. 4B is a cross-sectional view of a heat sink structure 400B along the line IV—IV of FIG. 1 in accordance with an alternative embodiment of the present invention. In this embodiment, pin 118B has a single diameter which is smaller than the diameter of aperture 122 in base section 124A. Thus, pin 118B does not press down on base section 124A. Instead, as pin 118B is attached to bolster plate 116, spring 402 is compressed between base section 124A and upper heat sink 130A. Due to the compression of spring 402, spring 402 causes lower heat sink 114A to press downwards on heat emitting component 110.

Since spring 402 is compressed between upper heat sink 130A and lower heat sink 114A, spring 402 exerts an equal and opposite force on both upper heat sink 130A and lower heat sink 114A. This allows the force exerted by lower heat sink 114A on heat emitting component 110 and the force exerted by upper heat sink 130A on cabinet 150 to be readily controlled by selecting an appropriate spring 402. However, in some applications, it may be desirable to have the force exerted by lower heat sink 114A on heat emitting component 110 to be different than the force exerted by upper heat sink 130A on cabinet 150.

FIG. 4C is a cross-sectional view of a heat sink structure 400C along the line IV—IV of FIG. 1 in accordance with another embodiment of the present invention. Heat sink structure 400C of FIG. 4C is substantially similar to heat sink structure 400B of FIG. 4B except that in FIG. 4C an additional inner spring 428 is used.

Referring to FIG. 4C, inner spring 428, e.g., a coil spring, has an inner diameter greater than the diameter of pin 118B. Further, inner spring 428 has an outer diameter less than the diameter of aperture 406 of upper heat sink 130B and greater than the diameter of aperture 122. Accordingly, inner spring 428 surrounds pin 118B and extends between head 408 of pin 118B and base section 124A of lower heat sink 114A.

The outer diameter of inner spring 428 is also less than the inner diameter of spring 402 such that spring 402, inner spring 428 and pin 118B have a common longitudinal axis 410. Further, spring 402 and inner spring 428 are capable of being compressed independently. In particular, spring 402 is compressed between lower heat sink 114A and upper heat sink 130A and inner spring 428 is compressed between head 408 and lower heat sink 114A.

In this embodiment, as pin 118B is attached to bolster plate 116, inner spring 428 is compressed between head 408 of pin 118B and base section 124A. Due to the compression of inner spring 428, inner spring 428 causes lower heat sink 114A to press downwards on heat emitting component 110. At the same time, spring 402 is compressed between base section 124A and upper heat sink 130A. Thus, spring 402 exerts an equal and opposite force on both upper heat sink 130A and lower heat sink 114A.

As a net result, the force exerted by lower heat sink 114A on heat emitting component 110 is controlled by the combination of spring 402 and inner spring 428 together. In contrast, the force exerted by upper heat sink 130A on cabinet 150 is controlled by spring 402 alone. By appropriately selecting spring 402 and inner spring 428, these forces are readily controlled.

FIG. 4D is a cross-sectional view of a heat sink structure 400D along the line IV—IV of FIG. 1 in accordance with an alternative embodiment of the present invention. Heat sink structure 400D of FIG. 4D is substantially similar to heat sink structure 400B of FIG. 4B. Only the relevant differences between heat sink structure 400B of FIG. 4B and heat sink structure 400D of FIG. 4D are discussed below.

Referring to FIG. 4D, a pin 118C includes a stop 420 located between a lower heat sink 114B and a base section 422 of an upper heat sink 130B. Located and compressed between stop 420 and lower heat sink 114B is a lower heat sink spring 424. Lower heat sink spring 424 presses lower heat sink 114B downwards against heat emitting component 110. Similarly, located and compressed between stop 420 and upper heat sink 130B is an upper heat sink spring 426. Upper heat sink spring 426 urges upper heat sink 130B upwards away from lower heat sink 114B and thus presses upper heat sink 130B upwards against cabinet 150.

Advantageously, the force exerted by lower heat sink 114B against heat emitting component 110 is independent of the force exerted by upper heat sink 130B against cabinet 150. In particular, lower heat sink spring 424 determines the force exerted by lower heat sink 114B against heat emitting component 110 and upper heat sink spring 426 determines the force exerted by upper heat sink 130B against cabinet 150. By appropriately selecting lower heat sink spring 424 and upper heat sink spring 426, these forces are readily controlled.

To assemble heat sink structure 400D, pin 118C is passed downwards through lower heat sink spring 424, through aperture 122 in lower heat sink 114B and through aperture 120 in substrate 112. Pin 118C is attached to bolster plate 116. A head 408A is threadedly connected to pin 118C in a conventional manner and is detachable. Head 408A is detached from pin 118C if not already detached. Upper heat sink spring 426 is passed downwards over pin 118C. Upper heat sink 130B is moved downwards so that pin 118C passes through aperture 406. Head 408A is attached to pin 118C.

In FIG. 4B, lower heat sink 114A includes a plurality of fins 128 extending upwards from base section 124A. However, in an alternative embodiment, lower heat sink 114A is a plate type heat sink and upper heat sink 130A is a fin type heat sink. To illustrate, referring now to FIG. 4D, lower heat sink 114B is a plate type heat sink and upper heat sink 130B is a fin type heat sink. In particular, upper heat sink 130B includes base section 422 and a plurality of fins 128 extending downwards from base section 422. The outermost fin 128L located at end 422E of base section 422 extends downwards alongside of lower heat sink 114B to prevent inadvertent horizontal motion of upper heat sink 130B relative to lower heat sink 114B. In particular, fin 128L is longer than inner fins 128S. (A second outermost fin 128L is located at the end of base section 422 opposite end 422E but is not shown in the view of FIG. 4D.) However, in an alternative embodiment, lower heat sink 114B and upper heat sink 130B of FIG. 4D are a fin type heat sink and a plate type heat sink, respectively.

FIG. 5 is a side plan view of a heat sink structure 500 in accordance with an alternative embodiment of the present invention. Heat sink structure 500 of FIG. 5 is identical with heat sink structure 100 of FIG. 2 with the exception that lower heat sink 114C and upper heat sink 130C of heat sink structure 500 of FIG. 5 are a plate type heat sink and a fin type heat sink, respectively. More particularly, referring now to FIG. 5, upper heat sink 130C includes a base section 502 and a plurality of fins 128 extending downwards from base section 500. The outermost fins 128L located at ends 502E of base section 502 extend downwards alongside of lower heat sink 114C to prevent inadvertent horizontal motion of upper heat sink 130C relative to lower heat sink 114C. In particular, fins 128L are longer than inner fins 128S.

This application is related to Bollesen, co-filed and commonly assigned U.S. patent application Ser. No. 09/464,330,

entitled "METHOD FOR THERMALLY CONNECTING A HEAT SINK TO A CABINET", which is herein incorporated by reference in its entirety.

The drawings and the forgoing description gave examples of the present invention. The scope of the present invention, however, is by no means limited by these specific examples. Numerous variations, whether explicitly given in the specification or not, such as differences in structure, dimension, and use of material, are possible. The scope of the invention is at least as broad as given by the following claims.

What is claimed is:

1. A heat sink structure comprising:

a first heat sink;

a second heat sink;

at least one heat pipe extending from said first heat sink to said second heat sink, said at least one heat pipe comprising a first heat pipe, wherein a first end of said first heat pipe is secured to said first heat sink and wherein a second end of said first heat pipe is secured to said second heat sink; and

at least one spring which urges said second heat sink away from said first heat sink.

2. The heat sink structure of claim 1 further comprising a heat emitting component in thermal contact with said first heat sink.

3. The heat sink structure of claim 2 further comprising: a substrate, said heat emitting component being attached to a first surface of said substrate; and

a bolster plate position opposite of said heat emitting component on a second surface of said substrate.

4. The heat sink structure of claim 3 further comprising a pin extending in a first direction from said bolster plate, said pin passing through an aperture in said substrate, said pin passing through an aperture of said first heat sink, wherein a head of said pin presses in a second direction opposite said first direction against said first heat sink.

5. The heat sink structure of claim 1 wherein said first heat sink comprises:

a base section; and

a plurality of fins extending from said base section.

6. The heat sink structure of claim 5 wherein said second heat sink comprises a flat metal plate.

7. The heat sink structure of claim 5 wherein a first fin of said plurality of fins is longer than a second fin of said plurality of fins.

8. The heat sink structure of claim 1 wherein said second heat sink comprises:

a base section; and

a plurality of fins extending from said base section.

9. The heat sink structure of claim 8 wherein a first fin of said plurality of fins is longer than a second fin of said plurality of fins.

10. The heat sink structure of claim 1 wherein said first end of said first heat pipe is secured in an aperture of said first heat sink and wherein said second end of said first heat pipe is secured in an aperture of said second heat sink.

11. The heat sink structure of claim 1 further comprising a cabinet in thermal contact with said second heat sink.

12. The heat sink structure of claim 11 wherein said second heat sink is bolted to said cabinet.

13. A heat sink structure comprising:

a first heat sink;

a second heat sink;

at least one heat pipe extending from said first heat sink to said second heat sink; and

11

at least one spring which urges said second heat sink away from said first heat sink, said at least one spring comprising a first spring, a first end of said first spring being secured to said first heat sink, a second end of said first spring being secured to said second heat sink.

14. The heat sink structure of claim 13 wherein said first end of said first spring is secured in an aperture of said first heat sink, and wherein said second end of said first spring is secured in an aperture of said second heat sink.

15. A heat sink structure comprising:

a first heat sink;

a second heat sink;

at least one heat pipe extending from said first heat sink to said second heat sink;

at least one spring which urges said second heat sink away from said first heat sink; and

a pin which extends through an aperture of said first heat sink and into a pinhead cavity of said second heat sink.

16. The heat sink structure of claim 15 wherein said pin comprises a head in said pinhead cavity, said pinhead cavity having a greater diameter than a diameter of said head.

12

17. The heat sink structure of claim 16 wherein said pin extends through an aperture of said second heat sink, said diameter of said head being greater than a diameter of said aperture of said second heat sink.

18. The heat sink structure of claim 15 wherein said at least one spring comprises a first spring which surrounds said pin.

19. The heat sink structure of claim 18 wherein said first spring and said pin have a common longitudinal axis.

20. The heat sink structure of claim 18 wherein said pin comprises a stop, said first spring being located between said stop and said second heat sink.

21. The heat sink structure of claim 20 further comprising a second spring located between said stop and said first heat sink.

22. The heat sink structure of claim 18 wherein a second spring surrounds said pin, an outer diameter of said second spring being less than an inner diameter of said first spring.

23. The heat sink structure of claim 22 wherein said second spring extends between a head of said pin and said first heat sink.

* * * * *